Claims

1.   A method of transmitting a signal, the method comprising:-
        providing digital data to be transmitted to a remote station as a plurality of
parallel bitstreams;
        phase modulating said bitstreams with respective orthogonal or substantially
orthogonal spectrum spreading signals to produce a plurality of modulating signals;
        phase modulating respective instances of a carrier with said modulating
signals to produce a plurality to modulated carrier instances; and
        summing the modulated carrier instances and transmitting the result of said
summation.

2.   A method according to claim 1, wherein each spreading signal is produced by
phase modulating a common finite spreading sequence with a respective cyclic
signal, said cyclic signals being such that each completes an integer number of cycles
in the duration of said spreading sequence.

3.   A method according to claim 1, wherein one of the spreading signals is
comprises a finite spreading sequence and the other spreading signals are each
produced by phase modulating said finite spreading sequence with a respective
cyclic signal, said cyclic signals being such that each completes an integer number of
cycles in the duration of said spreading sequence.

4.   A method according to claim 2 or 3, wherein said cyclic signals are
substantially sinusoidal.

5.   A method according to claim 4, wherein said cyclic signals are stepped sine
waves, each step having the same duration as chips of said spreading sequence.

6.   A method according to any one of claims 1 to 5, wherein said spreading
sequence $c[.]$ is derived from a first code $a[.]$ and a second code $b[.]$ according to
$$c[n] = \left[a[0]\bar{b}, a[1]\bar{b}, \ldots, a[M-1]\bar{b}\right].$$

7.   A method according to claim 6, wherein the Fourier transforms of the first and second codes satisfy:

$$s[t] \leftrightarrow S(e^{j\omega}) \neq 0 \text{ for all } \omega$$

where s and S represent the first and second codes in the time and frequency domains respectively.

8.   A method according claim any one of claims 1 to 7, wherein said bitstreams comprise bits of a single digital signal such that groups of bits of said single digital signal are transmitted in parallel.

9.   A transmitter comprising:

a source of digital data to be transmitted to a remote station as a plurality of parallel bitstreams;

first means for phase modulating said bitstreams with respective orthogonal or substantially orthogonal spectrum spreading signals to produce a plurality of modulating signals;

second means for phase modulating respective instances of a carrier with said modulating signals to produce a plurality to modulated carrier instances; and

a summer for summing the modulated carrier instances.

10.   A transmitter according to claim 9, wherein the first means comprises means for producing each spreading signal by phase modulating a common finite spreading sequence with a respective cyclic signal, said cyclic signals being such that each completes an integer number of cycles in the duration of said spreading sequence.

11.   A transmitter according to claim 9, wherein the first means comprises means for producing one of the spreading signals by generating a finite spreading sequence and producing the other spreading signals by phase modulating said finite spreading sequence with a respective cyclic signal, said cyclic signals being such that each completes an integer number of cycles in the duration of said spreading sequence.

12.   A transmitter according to any one of claim 10 or 11, wherein said cyclic signals are substantially sinusoidal.

13.   A transmitter according to claim 12, wherein said cyclic signals are stepped sine waves, each step having the same duration as chips of said spreading sequence.

14.   A transmitter according to any one of claims 9 to 13, wherein said spreading sequence $c[.]$is derived from a first code $a[.]$ and a second code $b[.]$ according to

$$c[n] = \left[a[0]\overline{b}, a[1]\overline{b}, \ldots, a[M-1]\overline{b}\right].$$

15.   A transmitter according to claim 14, wherein the Fourier transforms of the first and second codes satisfy:

$$s[t] \leftrightarrow S(e^{j\omega}) \neq 0 \text{ for all } \omega$$

where s and S represent the first and second codes in the time and frequency domains respectively.

16.   A transmitter according claim any one of claims 9 to 15, wherein the source of digital data signals includes means for generating said bitstreams from a single digital signal such that groups of bits of said single digital signal are transmitted in parallel.

17.   A transmitter according to claim 16, wherein said means for generating said bitstreams comprises a digital signal processor.

18.   A transmitter according to any one of claims 9 to 17, wherein the first means comprises a digital signal processor .

19.   A transmitter according to any one of claim 9 to 18, wherein the second means comprises a plurality of analogue phase modulators.

20.   A mobile phone including a transmitter according to any one of claims 9 to 19.

21.   A base station of a mobile phone network including a transmitter according to any one of claims 9 to 19.

22. A method of receiving a signal produced by a method according to claim 1, the method comprising the steps of:-

producing a baseband signal, comprising components corresponding to the modulating signals, from a received rf signal; and

processing the baseband signal by processes adapted to extract the data from each of the modulating signals.

23. A method according to claim 22, wherein at least all but one of said processes comprises:-

phase modulating the baseband signal by the inverse of a respective one of said cyclic signal to produce a first signal;

phase modulating instances of the first signal by respective cyclic signals of the form $e^{j2\pi nP/L}$ where P comprises the set of values in the range 0, ... , L-1, and L is the length of the second code to produce L second signals;

filtering each of said second signals with a filter having a transfer function which is the inverse of the first code to produce respective third signals;

correlating the third signals with corresponding reference signals and summing the results of the said correlations.

24. A method according to claim 22 or 23, including mapping the outputs of said processes onto a transmitted parallel bit pattern using a maximum likelihood algorithm and outputting said parallel bit pattern.

25. A method according to claim 22, 23 or 24, wherein data bits extracted by said processes are combined into a single data signal.

26. A receiver for receiving a signal produced by a method according to claim 1, the receiver comprising:-

rf processing means for producing a baseband signal, comprising components corresponding to the modulating signals, from a received rf signal; and

processing means for processing the baseband signal by processes adapted to extract the data from each of the modulating signals.

27.   A receiver according to claim 26, wherein at least all but one of said processes comprises:-

        phase modulating the baseband signal by the inverse of a respective one of said cyclic signal to produce a first signal;

        phase modulating instances of the first signal by respective cyclic signals of the form $e^{j2\pi nP/L}$ where P comprises the set of values in the range 0, ... , L-1, and L is the length of the second code to produce L second signals;

        filtering each of said second signals with a filter having a transfer function which is the inverse of the first code to produce respective third signals;

        correlating the third signals with corresponding reference signals and summing the results of the said correlations.

28.   A receiver according to claim 26 or 27, wherein the processing means is configured for mapping the outputs of said processes onto a transmitted parallel bit pattern using a maximum likelihood algorithm and outputting said parallel bit pattern.

29.   A receiver according to claim 26, 27 or 28, wherein the processing means is configured to combine the extracted data bits into a single data signal.

30.   A receiver according to any one of claims 26 to 29, wherein the processing means comprises a digital signal processor.

31.   A mobile phone including a receiver according to any one of claims 26 to 30.

32.   A base station of a mobile phone network including a receiver according to any one of claims 26 to 30.

33.   A mobile phone network including a base station according to claim 32 in communicative relation to a plurality of mobile phones according to claim 20, wherein the mobile phones employ the same carrier frequency and spreading signals for communication with the base station, each mobile phone applying the spreading

signals in a time offset manner relative to the use of the spreading signals by each of the other mobile phones.

34.   A method of RS-CTDMA operation in which, for a spreading code of length N=ML,

(a)   L orthogonal codes, specified by $\{f_i\}=\{i+\ell*M\}$ ($\ell = 0,...\ L-1$) for $i\in[0, M\text{-}1]$), are used to transmit up to L data bits in parallel for a user in the ith cell;

(b)   users within one cell are time-offset by at least L chips to avoid or reduce intracell interuser interference; and

(c)   M orthogonal spectral groups are used in different cells.